The clinical utility of three visual attention tests to distinguish adults with ADHD from normal controls

L'utilità clinica di tre test di attenzione visiva per distinguere adulti con ADHD dai controlli

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SUMMARY. Background. Adult patients with ADHD may go unrecognised and undiagnosed. This can result in psychosocial and functional decline. **Objectives.** To investigate the clinical use of three objective computerised tests in the diagnosis of adult patients with ADHD. **Methods.** Case-control study. Inclusion criteria: aged 18-65, ADHD diagnosis; exclusion criteria: visual impairments, colour vision deficiencies, acute mental illness, amnesia, and learning difficulties. ADHD was diagnosed with Conners' Adult ADHD Diagnostic Interview (n=14) and were matched for gender and age against normal controls (n=30). Three computer-based tasks, Stroop test, Stroop Plus, and Perceptual Selectivity test were completed. Accuracy (%) and response time (ms) were measured. Generalized Estimating Equations method was used to analyse those repeated measurements data. The Area Under the Curve (AUC) was calculated for each test. **Results.** Mean age of cases was 47.29 (SD 9.03), 9 males. Mean age of controls was 41.57 (SD 11.42), 13 males. Individuals with ADHD had significantly worse performances in both accuracy and response time in all the tests. The best discriminate ability was the Stroop test (accuracy and response time), followed by the Perceptual Selectivity test (response time). Comparisons of AUCs of the tests did not show any significant differences. Age had a significant effect on the Stroop and Stroop Plus tests but not in the Perceptual Selectivity test. **Conclusions.** Adults with ADHD have a longer response time and perform less accurately than controls. Thus, these data suggest that there is a use for objective visual attention tests in the diagnosis of adult ADHD.

KEY WORDS: attention deficit hyperactivity disorder, ADHD, Interference test, Stroop test, Perceptual Selectivity test, psychometrics.

RIASSUNTO. Introduzione. Nei pazienti adulti l'ADHD può non essere riconosciuto e diagnosticato. Ciò può comportare un declino psicosociale e funzionale. **Scopo.** Studiare l'uso clinico di tre test computerizzati oggettivi nella diagnosi di pazienti adulti con ADHD. **Metodi.** Studio caso-controllo. Criteri di inclusione: età 18-65 anni, diagnosi di ADHD; criteri di esclusione: disturbi della vista, deficit della visione dei colori, malattia mentale acuta, amnesia e difficoltà di apprendimento. L'ADHD è stato diagnosticato con l'intervista diagnostica ADHD per adulti di Conners (n=14) ed è stato confrontato per sesso ed età rispetto ai controlli (n=30). Sono state completate tre attività basate su computer, test Stroop, Stroop Plus e test di selettività percettiva. Sono stati misurati la precisione (%) e il tempo di risposta (ms). Il metodo delle equazioni di stima generalizzate è stato utilizzato per analizzare i dati delle misurazioni ripetute. L'Area Under the Curve (AUC) è stata calcolata per ciascun test. **Risultati.** L'età media dei casi era di 47,29 (DS 9,03), 9 maschi. L'età media dei controlli era di 41,57 (SD 11,42), 13 maschi. Gli individui con ADHD hanno mostrato prestazioni significativamente peggiori in termini di accuratezza e tempo di risposta in tutti i test. L'abilità discriminante migliore era il test Stroop (precisione e tempo di risposta), seguito dal test di selettività percettiva (tempo di risposta). Il confronto delle AUC dei test non ha mostrato differenze significative. L'età ha avuto un effetto significativo sui test di Stroop e Stroop Plus ma non nel test di selettività percettiva. **Conclusioni.** Gli adulti con ADHD hanno un tempo di risposta più lungo e funzionano in modo meno accurato rispetto ai controlli. Pertanto, questi dati suggeriscono che esiste un uso per test oggettivi di attenzione visiva nella diagnosi di ADHD negli adulti.

PAROLE CHIAVE: disturbo da deficit di attenzione/iperattività, ADHD, Interference test, Stroop test, test di selettività percettiva, psicometria.

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neuropsychiatric disorder characterised by motor restlessness and symptoms of inattention and impulsivity. ADHD first manifests itself during childhood and affects about 5% of the general population[1,2]. Of these, 60% continue to be symptomatic into adulthood with symptoms of inattention being more prevalent than symptoms of hyperactivity or impulsivity[3,4]. Although ADHD is a disorder diagnosed during childhood, it has been reported that it can be missed or misdiagnosed[3,5]. As a result, individuals with ADHD may present for the first time to adult mental health services with various symptomatology and as such, are often misdiagnosed[6,7].

In both children and adults diagnosed with ADHD, cognitive deficits including impairments in attention and executive function are present, with behavioural manifestations (hyperactivity) seen more often in childhood[8-10]. Various neuropsychological tests have been proposed to distinguish ADHD from normal subjects and to study the neurocognitive deficits associated with it; the best known in cognitive science is the Stroop test. Stroop test is a test where participants have to report the font colour in which a word is printed and ignore the semantic meaning of the word[11]. Significant differences in executive functioning between normal subjects and those with ADHD have been reported by using the Stroop test in children. However, in adults this has not always been the case[12,13] with meta-analytical studies showing contradictory results[12,14]. The theoretical basis of the Stroop test in ADHD is the interference theory and the selective attention theory; the former explores the conflict between past learnt behaviour with new material presented, whereas the latter explores an individual's ability to extract relevant information when faced with multiple stimuli. In individuals with ADHD, interference deficits and impairments in cognitive control were found[9,13] which result in delayed responses. However, the explanation of delayed responses seen in those patients with ADHD has been long debated and alternative explanations have been proposed such as underlying dysfunctions of motivational and energetic states of individuals[15,16], deficits in working memory processes[17] or deficits in arousal adjustment[18].

Nevertheless, irrespective of the underlying mechanism(s) the Stroop's paradigm provides a platform for studying attention in individuals with ADHD. Thus, the aim of this study was to investigate three different tests, their clinical utility and diagnostic accuracy to distinguish adults with ADHD from normal subjects. More specifically, we investigated here the differences between individuals with ADHD and normal controls in terms of response time (overall), the accuracy in each test and the predictive validity of each test.

METHOD

Design and participants

This was a cross sectional study. Inclusion criteria included participants aged between 18 and 65 years of age with minimum of 5 years of education and literate in English. Exclusion criteria were visual impairments, colour vision deficiencies (achromatopsia or dyschromatopsia), acute mental illness, amnesia, and learning difficulties. The participants consisted of 14 adults diagnosed with ADHD (case group) by using the Conners' Adult ADHD Diagnostic Interview for DSM-IV (CAADID) who were matched for age and gender with 30 healthy volunteers (control group). Comorbidity of the cases with ADHD was assessed with the Mini International Neuropsychiatric Interview 5.0 (MINI v.5). A brief interview was conducted with the control group to exclude current or past psychiatric history. The group of cases was recruited from the outpatient clinics. All the cases were newly diagnosed with ADHD and none of them were on medications for ADHD. The group of controls was recruited from the staff working in the hospital and from medical students.

Participants completed three computer-based tasks built by using OpenSesame Experiment builder software and Python 3.2 language. The tests included (1) Stroop test, (2) Stroop Effect test with visual aid (called thereafter Stroop Plus test), and (3) Perceptual Selectivity test. The investigation was performed in a sound-attenuated, dimly lit room with the participant positioned 50 cm from the display screen with their head resting on a chin stand. The pixel resolution of the display screen was 1024x768 with a refresh rate of 100 Hz and the display monitor was positioned at eye level. Participants were given three minutes for their eyes to adjust to the room light before the experiment began. For each test, an instruction screen was shown at the start and then participants completed a practice trial with 16 runs and 3 experiment trials each with 16 runs. Each run had a maximum time limit of 2000 milliseconds. The total run time was 10 minutes. If the participant answered incorrectly an error sound was played and if they answered correctly no sound was played. Participants recorded their responses using keyboard keys. Accuracy (%) and response time in milliseconds (ms) was measured in each trial.

Tests

Stroop Test (Stroop Colour-Word): Each run consisted of an initial screen where a fixation dot measuring 0.5 cm x 0.5 cm was shown at the centre of the screen for 745 milliseconds. The second screen consisted of the stimulus: one colour word at a pixel resolution of 85 was shown at the centre of the screen. Any of the four colour words were shown randomly (red, green, blue, yellow). The font colour of the words were either congruent to the word itself or incongruent. The ratio of congruent to incongruent tasks was 1:3. Participants were asked to respond to the colour of the word and not the word itself as fast as they could (for example, the word "blue" written in red letters in Figure 1). This task demanded the selection of relevant information (e.g. attention to the colour of the ink) and ignoring the verbal content.

Stroop Plus Test: This test was designed similar to the Stroop test, however, it also included an inhibitory stimulus in the form of an arrow pointing to a coloured box. The word stimulus was positioned at the centre of the screen with 4 coloured boxes (red, green, blue, yellow) measuring 3 cm x 3 cm positioned at perpendicular angles 5cm from the word stimulus. An arrow measuring 3 cm pointed randomly at any of the coloured boxes during each run and acted as an inhibitory stimulus (Figure 2). The congruent to incongruent ratio of the word stimulus was again 1:3 but when considering the congruency of all the stimuli (word, arrow and coloured box) it was 1:9. Participants were asked to respond to the font colour of the word and not the verbal content of the word as fast as they could by pressing the relevant key. While the Stroop test was used to measure selective attention, the arrow was used to measure intentional motor inhibition, also known as executive inhibition[19]. Executive function deficits are seen in individuals with ADHD and the term "executive inhibition" refers to the ability to suppress an instantaneous response due to a misleading stimulus in order to respond to a later task demand.

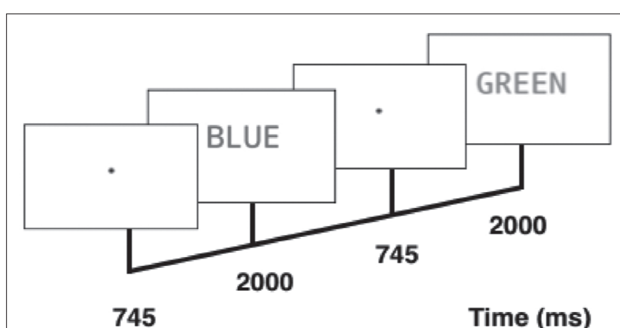

Figure 1. Stroop Test: Incongruent task-colour word "blue" in red font; Congruent task – colour word "green" in green font.

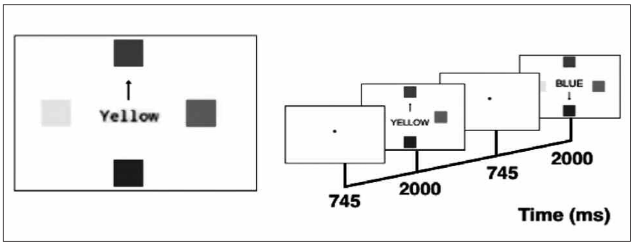

Figure 2. Stroop Plus Test: Stroop test superimposed with an arrow to act as an inhibitory stimulus.

Perceptual Selectivity Test: The Stroop test was presented at the centre of the screen. Four shapes with a radius of 1.5 cm were shown 5 cm from the word stimulus and were positioned perpendicularly to it. Three of the shapes were similar and one was different from the rest. The shapes could be either circles or squares. The colour font of the shapes were either all blue or all yellow in 50% of runs. In the other 50%, 3 were yellow and 1 blue and vice versa. In each of the shapes a line of 2.5 cm length was presented and was positioned at either -45º , 0º , 45º or 90º (Figure 3) . In this test the participants were asked to respond to the orientation of the line in the odd shape by pressing the corresponding key and the hence colours were irrelevant. The orientation could be either horizontal or vertical. This test was used to measure a subtype of selective attention known as perceptual selectivity[20,21]. This term refers to how discriminable a stimulus is: in other words, how effectively the participant can distinguish the goal task when presented with a single stimulus (change in shape only) and when faced with two stimuli (change in shape and the presence of an irrelevant colour).

Statistical analysis

The IBM (SPSS) version 24 software was used for the analysis of the data. Descriptive statistics are presented as counts for categorical variables (gender) and as means and standard deviations (SD) for continuous ones. Given that no intervention was conducted during the study period, the time variable was not of any interest and therefore the Generalized Estimating Equations method (GEE) was used to analyse those repeated measurements data. The GEE takes into account the fact that observations within a subject are correlated, and estimates the population average across time. For GEE analysis an exchangeable working correlation matrix structure was assumed, with link function identity. In each GEE analysis, dependent variables were the mean accuracy (expressed from 0 to 100) and the mean response time of each trial. The independent variable was the control or case status (Controls/ADHD). Similarly, GEE models were used to estimate the effects of age and gender on the performance of each test in each participant's group (Controls or ADHD). The non-significant effects were dropped from the final models. In addition, the Area Under the Curve (AUC) was calculated for each test for all the trials and then those areas were compared pairwise between themselves to find out which is the better discriminatory test. For this analysis the MedCalc v. 18.5 software was used with the method described by[22].

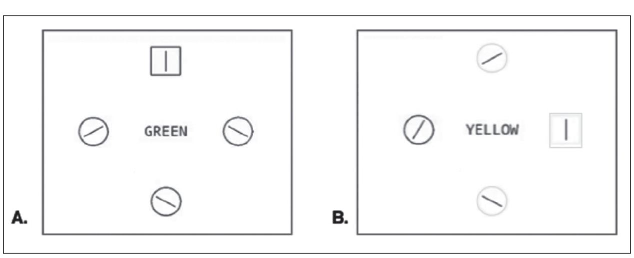

Figure 3. (A) The font colour of the shapes are uniform and the orientation of the line is vertical in the odd shape (square) (B) The font colour of one shape is different to the others and acts as an inhibitory response. The orientation of the line is vertical in the odd shape (square).

RESULTS

Descriptive statistics

The number of participants in the cases' group was 14, the mean age was 47.29 (SD 9.03) and from them 9 were males and 5 females. The number of participants in the control group was 30 with a mean age of 41.57 (SD 11.42) and from them 13 were male and 17 were female. No differences were found between the groups regarding age (t-test, t=1.646, df: 42, p=0.107) and gender (x^2=1.676, df: 1, p=0.195). Four participants in the case group were diagnosed with one psychiatric comorbidity and a further six participants had 2 psychiatric comorbidities. These included depression (n=4), generalized anxiety disorder (n=4), paranoid schizophrenia (n=2), bipolar affective disorder (n=1), obsessive compulsive disorder (n=1), substance abuse (n=4).

Table 1 shows the accuracy and the response time in milliseconds (means and standard deviations) of each test at each trial for both groups (controls and those with ADHD).

Generalized Estimating Equations (GEE) models

For each test, a separate GEE model was conducted between the independent variable (control/case status) and the dependent variables (accuracy and response time).

The results (parameter estimates and hypotheses test with their significance) of the GEE models are presented in Table 2. As it can be seen from Table 2, individuals with ADHD had significantly worse performances compared to controls in both accuracy and response time in each of the tests.

Using the same model as above (GEE), the effects of age and gender were examined in each of the three tests and in each of the two groups (controls/cases). Gender did not have a significant effect in either group in any of the tests. Therefore, it was dropped from the final models. The results of the effects of age are presented in Table 3. As it can be seen from the results, age had a statistically significant effect in accuracy (more advanced age, less accurate responses) and in the response time (younger age resulted in faster responses) in the Stroop and the Stoop Plus tests. In contrast, age did not have a significant effect on the Perceptual Selectivity test, either in the accuracy or in the response time. Thus, the accuracy and the response time of the Perceptual Selectivity test are independent of the age of the participant and they are solely dependent on whether the participant has ADHD or not.

Finally, the tests were compared between themselves by using the Area Under the Curve (AUC) in a Receiver Operating Characteristic (ROC) analysis. The area measures discrimination, in other words, the ability of the test to correctly classify those with and without the disorder. The comparison was done by using the DeLong et al.[22] method.

The areas under the curve and their significance for each test are shown in Table 4. Figure 4 shows the visual repre-

Table 1. Mean and Standard Deviations (SD) of each test in each trial of controls and cases groups.

a		Trials					
		1		**2**		**3**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Controls	Stroop test (accuracy)	89.58	16.77	92.08	12.05	96.04	6.86
	Stroop test (response time)	1246.97	285.76	1166.27	239.06	1121.67	226.47
	Stroop Plus test (accuracy)	82.08	24.16	91.04	17.58	95.00	9.20
	Stroop Plus test (response time)	1129.87	384.80	1025.07	358.41	936.73	311.05
	Perceptual Selectivity test (accuracy)	59.38	24.50	66.67	21.92	71.88	22.01
	Perceptual Selectivity test (response time)	1280.83	297.11	1098.07	277.56	1086.33	279.12
Cases (ADHD)	Stroop test (accuracy)	62.31	35.15	70.98	29.58	75.00	25.36
	Stroop test (response time)	1588.14	303.55	1495.36	283.52	1456.21	312.31
	Stroop Plus test (accuracy)	66.96	30.95	73.21	26.11	83.93	25.32
	Stroop Plus test (response time)	1421.14	336.35	1305.14	425.25	1269.07	384.21
	Perceptual Selectivity test (accuracy)	35.27	22.28	48.66	30.93	61.61	28.99
	Perceptual Selectivity test (response time)	1589.86	299.28	1420.79	271.63	1312.93	289.98

Table 2. Parameter estimates of the effects of cases and controls in each of the tests.

Stroop test (accuracy)							
			95% Wald C. I		Hypothesis Test		
Parameter	*B	Std. Error	Lower	Upper	Wald x^2	df	Sig.
Intercept	69.43	7.44	54.86	84.01	87.18	1	<.0001
Controls	23.14	7.64	8.18	38.10	9.19	1	.002
ADHD	0**	.	.	.	.	.	.
Stroop test (response time)							
Intercept	1513.24	73.34	1369.50	1656.97	425.79	1	<.0001
Controls	-334.94	85.06	-501.64	-168.23	15.51	1	<.0001
ADHD	0	.	.	.	.	.	.
Stroop Plus test (accuracy)							
Intercept	74.70	6.55	61.86	87.55	129.92	1	<.0001
Controls	14.67	7.11	.73	28.62	4.25	1	.039
ADHD	0	.	.	.	.	.	.
Stroop Plus test (response time)							
Intercept	1331.79	95.41	1144.78	1518.79	194.84	1	<.0001
Controls	-301.23	113.73	-524.13	-78.33	7.02	1	.008
ADHD	0	.	.	.	.	.	.
Perceptual Selectivity test (accuracy)							
Intercept	48.51	6.29	36.18	60.84	59.48	1	<.0001
Controls	17.46	7.24	3.28	31.64	5.82	1	.016
ADHD	0	.	.	.	.	.	.
Perceptual Selectivity test (response time)							
Intercept	1441.19	69.10	1305.76	1576.63	434.99	1	<.0001
Controls	-286.11	82.71	-448.22	-124.01	11.97	1	.001
ADHD	0	.	.	.	.	.	.

* The sign (+ or -) in front of the estimates (B) shows the direction of the relationship with the dependent variable; e.g. the minus (-) in front of the B in the controls in the Stroop test (response time) indicates that the controls where faster (less time) compared to the cases.

** Set to zero because this parameter is redundant.

sentation of the areas for all of the tests. From Table 4, it can be deduced that the test with the best discriminatory ability is the Stroop test (accuracy and response time), followed by the Perceptual Selectivity test (response time). However pairwise comparison of all combinations of the tests did not show any significant differences between them (results not shown). Therefore, all the tests have a similar ability to correctly classify between controls and ADHD cases.

DISCUSSION AND CONCLUSIONS

The results of this study show that the three tests are able to distinguish, with relatively good accuracy, normal controls from the adults with ADHD. However, the most important finding from this study is that age has a significant effect on both accuracy and response time in the two versions of Stroop test (Stroop and Stroop Plus tests) while this age effect is not found in the Perceptual selectivity test.

In a previous meta-analysis of the Stroop interference test in adults with ADHD[23], the effect size of the Stroop test was found to be medium (d=0.47) whereas meta-analyses in children with ADHD[24] have reported a higher effect size (d=from 0.57 to 0.75) with contradictory results (effect size, d=0.35)[25]. The main reason for these contradictions is the calculation/scoring of the tests. To avoid this pitfall we have used a simple scoring method – accuracy and response time

Table 3. Parameter estimates of the effects of age in each of the tests in each group.

	Stroop test (accuracy)							
					95% Wald C. I		Hypothesis Test	
	Parameter	*B	Std. Error	Lower	Upper	Wald x^2	df	Sig.
Controls	Intercept	110.86	5.36	100.35	121.37	427.38	1	<.0001
	Age	-.44	.14	-.72	-.16	9.49	1	.002
ADHD	Intercept	159.06	23.61	112.78	205.33	45.38	1	.000
	Age	-1.89	.60	-3.07	-.72	9.98	1	.002
Stroop test (response time)								
Controls	Intercept	666.21	127.32	416.68	915.75	27.38	1	<.0001
	Age	12.32	2.902	6.63	18.00	18.02	1	<.0001
ADHD	Intercept	425.21	255.54	-75.65	926.06	2.76	1	.096
	Age	23.01	5.1777	12.86	33.16	19.75	1	<.0001
Stroop Plus test (accuracy)								
Controls	Intercept	114.98	8.518	98.28	131.67	182.17	1	<.0001
	Age	-.62	.234	-1.07	-.16	6.90	1	.009
ADHD	Intercept	169.74	18.013	134.43	205.04	88.79	1	<.0001
	Age	-2.01	.436	-2.86	-1.15	21.29	1	<.0001
Stroop Plus test (response time)								
Controls	Intercept	246.31	175.96	-98.57	591.19	1.96	1	.162
	Age	18.87	4.48	10.08	27.65	17.71	1	<.0001
ADHD	Intercept	-57.69	322.29	-689.38	574.01	.03	1	.858
	Age	29.38	6.638	16.37	42.39	19.59	1	<.0001
Perceptual Selectivity test (accuracy)								
Controls	Intercept	78.63	13.70	51.77	105.49	32.92	1	<.0001
	Age	-.30	.31	-.91	.30	.97	1	.324
ADHD	Intercept	43.05	40.36	-36.05	122.15	1.14	1	.286
	Age	.12	.79	-1.44	1.67	.021	1	.884
Perceptual Selectivity test (response time)								
Controls	Intercept	900.26	160.61	585.47	1215.05	31.42	1	<.0001
	Age	6.13	3.96	-1.64	13.90	2.39	1	.122
ADHD	Intercept	1288.22	539.62	230.58	2345.86	5.69	1	.017
	Age	3.23	10.43	-17.21	23.68	.09	1	.756*

*The sign (+ or -) in front of the estimates (B) shows the direction of the relationship with the dependent variable; e.g. the minus (-) in front of the B in the age category of the Stroop test (accuracy) suggests that increasing age results in less accurate responses.

– and both were recorded precisely because we have computerized the tests. While the Stroop test has been extensively used in research and consistently differentiated between groups of adults with ADHD and controls the other variation that we used (Stroop Plus test), to the best of our knowledge, has not been previously used to compare our results with previous studies. Similarly the Perceptual Selectivity test has not been previously used in ADHD research. Despite that, the results of the present study suggest that the three of these tests can distinguish adults with ADHD from normal controls, with the same degree of accuracy. The original Stroop test had the highest discriminatory ability but this was not significantly better from the rest. However, the three tests that we have used are based on the assumption that adults with ADHD have interference control deficits and this can explain the similar results in both accuracy and response time in each of the tests. The only major difference among the tests was the effect of age which we will discuss below in more detail, given that the adult population has a larger age span compared to children.

Table 4. Areas Under the Curve for each of the tests and for each dependent variable.

				95% CI	
Test Result Variable(s)	Area	Std. Error	Sig	Lower bound	Upper bound
Stroop test (accuracy)	.814	.069	.001	.679	.949
Stroop test (response time)	.810	.074	.001	.664	.955
Stroop Plus test (accuracy)	.723	.078	.018	.569	.876
Stroop Plus test (response time)	.724	.082	.018	.563	.885
Perceptual Selectivity test (accuracy)	.707	.084	.028	.542	.872
Perceptual Selectivity test (response time)	.783	.072	.003	.643	.924

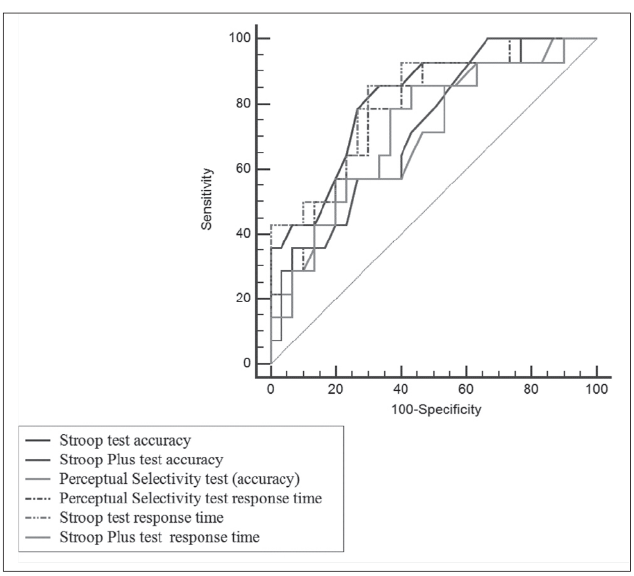

Figure 4. Comparison of ROC curves for each of the tests and for each dependent variable.

Age in the Stoop test and in its variations has received little attention in the studies which have examined differences in attentional performance between adult subjects with ADHD and normal controls[26]. Balint et al.[26] in their meta-analysis found no effect of age in the differences in the attention performances between those two groups. However, the authors have examined together many (n=12) neurocognitive tests and not specifically the Stroop test or its variations. One study which examined the performance on Stroop test in normal adults showed a decline in the performance with age[27]. In addition it was reported[28] that Stroop test performance in individuals with ADHD improves with age (age span examined was from 10 to 29 years of age), but in our study which examined an older population, the performance was declined with age in both control and ADHD participants. The implication of those findings is in the new notion of the adult onset ADHD[29]. It has been proposed that adults presenting with ADHD symptoms may not necessarily have a childhood-onset neurodevelopmental disorder but rather they may manifest their symptoms for first time in adulthood. Although this has not been confirmed yet[30], in those cases it is preferable to use the Perceptual selectivity test which is independent of age, rather than the Stroop test.

Regarding gender we did not find any effect on any of the test in both controls and cases. Although we did not expect any differences, a previous meta-analysis found a relationship between the overall gender ratio and performance in the Stroop test, but this needs to be confirmed by other studies[26]. ADHD is predominantly seen as a disorder more commonly affecting males than females, with a reported male to female ratio of 3:1 to 9:1[31]. More recent studies narrow this gap[32]. The range of male, female ratio in our sample is inside those limits. In addition we did not find any effect of gender in the control group.

Limitations of the study

A major limitation of our study is the small sample size which did not allow us to evaluate the impact of comorbid disorders in the used tests. Until now only a small number of studies have investigated this effect, with contradictory findings. Taylor and Miller[33] reported that the number of comorbid diagnoses was positively related to the degree of attentional impairment in their ADHD group while, on the contrary[34,35] reported that comorbidity did not necessarily contribute to the pattern of cognitive deficits associated with ADHD. Comorbidity is often the case in adult ADHD but to examine the effects of each comorbid disorder or combinations of comorbid disorders in any neurocognitive test would require a huge number of participants which may make any such study impossible to conduct.

Although it would be interesting to know whether disorders that are comorbid with ADHD have any effect on attention, the present study examines the clinical utility of a common test and two variations of it in a pragmatic clinical sample with comorbidities. As such we can conclude that all three tests that we used had good discriminatory value in distinguishing those with adult ADHD from normal subjects and we can suggest our preference for the Perceptual selectivity test, and especially the response time which is independent of the age of the subject. However, because this is perhaps the first study which uses the Perceptual selectivity test in ADHD, future research should be done with different samples to find out if our conclusions still hold.

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